MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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A. A. COMMON, LL.D., F.R.S., President, in the Chair.

William Anderson, Ballee House, Ballymena, co. Antrim, Ireland ;
Thomas Frederick Furber, Trigonometrical Survey of New South Wales, Department of Lands, Sydney, Australia ;
Frank L. Grant, M.A., 58 Kelvingrove Street, Glasgow ;
Edward Ayearst Reeves, 24 Clyde Road, Wallington, Surrey ;
George Frederick Herbert Smith, B.A., New College, Oxford ; and
T. M. Teed, C.E., F.R.G.S., 188 Camberwell Grove, Denmark Hill, S.E.,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Rev. Frederick Lisle Bullen, Littleton Rectory, Thornbury, Gloucestershire (proposed by W. F. Denning) ; and
Ernest W. Ellerbeck, Borough Meteorologist &c., Scarborough, Yorkshire (proposed by W. E. Plummer).

Sixty presents were announced as having been received since the last meeting, including amongst others :—

Rev. S. J. Johnson, "Historical and Future Eclipses," presented by the author ; album containing a collection of autograph letters &c., from Sir G. B. Airy, Dr. J. R. Hind, Mr. J. W. Bosanquet, &c., relating to ancient eclipses, presented by Mr. Maw.

LEEDS PHILOSOPHICAL AND LIT. SOCIETY

Note on Mr. Stone's Paper, "Expressions for the Elliptic Coordinates of a Moving Point to the Seventh Order of Small Quantities." By Professor Ernest W. Brown.

In the January number of the *Monthly Notices* Mr. Stone gives the expressions for the polar coordinates of a point moving in an ellipse about one focus, as far as quantities of the seventh order inclusive, with respect to the eccentricity and inclination. It may perhaps be useful to mention that these expressions are substantially contained in a memoir by Cayley, "Tables of the Developments of Functions in the Theory of Elliptic Motion" (*Memoirs R.A.S.* vol. xxix. 1861, pp. 191–306; *Coll. Works*, vol. iii. pp. 360–474). It is true that the expressions there given refer only to the case of motion in the plane of reference, but the steps necessary to obtain the longitude and latitude when the ellipse is inclined to the plane of reference require little more than the reading off of the coefficients from the tables.

The expressions for positive and negative powers of r/a are given on pp. 425–427 (*Coll. Works*), and that for the orbital elliptic longitude on p. 474.

To obtain the longitude in the plane of reference, we have, in Delaunay's notation,

$$\tan (\mathrm{V}-h) = \cos i \tan \nu ;$$

whence

$$\mathrm{V}-h = \nu - \tan^2 \tfrac{\mathrm{I}}{2} i \sin 2\nu + \tfrac{\mathrm{I}}{2} \tan^4 \tfrac{\mathrm{I}}{2} i \sin 4\nu - \tfrac{\mathrm{I}}{3} \tan^6 \tfrac{\mathrm{I}}{2} i \sin 6\nu + \quad . \quad .$$

or

$$\mathrm{V} = h + \nu - (\gamma^2 + \gamma^4 + \gamma^6) \sin 2\nu + \left(\tfrac{\mathrm{I}}{2}\gamma^4 + \gamma^6\right) \sin 4\nu - \tfrac{\mathrm{I}}{3}\gamma^6 \sin 6\nu + \quad . \quad . \quad (1)$$

Put

$$\nu = g + f,$$

where f is the true anomaly, and let

$$\cos jf = \Sigma_i \mathrm{A}_i \cos il, \qquad \sin jf = \Sigma_i \mathrm{B}_i \sin il,$$

where i, j are positive integers. We obtain

$$\sin j\nu = \tfrac{\mathrm{I}}{2} \Sigma_i (\mathrm{A}_i + \mathrm{B}_i) \sin (jg + il) + \tfrac{\mathrm{I}}{2} \Sigma_i (\mathrm{A}_i - \mathrm{B}_i) \sin (jg - il).$$

The coefficients

$$\tfrac{\mathrm{I}}{2}(\mathrm{A}_i + \mathrm{B}_i), \qquad \tfrac{\mathrm{I}}{2}(\mathrm{A}_i - \mathrm{B}_i)$$

are tabulated by Cayley * for all values of i, j from 1 to 7, as far as the order e^7 inclusive; so that the coefficient of any term in

* His notation differs from that used above.

V is obtained by taking out the part dependent on the eccentricity from the tables and multiplying it by the corresponding coefficient in (1).

To obtain the latitude, we have

$$\sin U = \sin i \sin \nu;$$

whence (Hobson's *Trigonometry*, p. 268)

$$U = \sin i \sin \nu + \frac{1}{6}\sin^3 i \sin^3 \nu + \frac{3}{40}\sin^5 i \sin^5 \nu + \frac{5}{112}\sin^7 i \sin^7 \nu + \ldots$$

Putting

$$\gamma = \sin \frac{1}{2} i,$$

this gives

$$U = \left(2\gamma - \frac{1}{4}\gamma^5 - \frac{3}{8}\gamma^7\right)\sin \nu - \left(\frac{1}{3}\gamma^3 + \frac{1}{4}\gamma^5 + \frac{1}{8}\gamma^7\right)\sin 3\nu + \left(\frac{3}{20}\gamma^5 + \frac{1}{4}\gamma^7\right)\sin 5\nu - \frac{5}{56}\gamma^7 \sin 7\nu + \ldots$$

which is expanded, by means of Cayley's tables, in terms of sines of multiples of g, h and powers of e, γ, in the same way as the corresponding terms of the longitude.

It will be noticed that the coefficients of γ^7 in $\sin \nu$ and $\sin 3\nu$ differ from those obtained by Mr. Stone. He finds

$$+\frac{3}{8}\gamma^7 \sin (g + l), \qquad -\frac{3}{8}\gamma^7 \sin 3(g + l).$$

I obtain, by the above method, for these terms

$$-\frac{3}{8}\gamma^7 \sin (g + l), \qquad -\frac{1}{8}\gamma^7 \sin 3(g + l).$$

respectively. I have verified all the expressions and, with the exception of the terms just mentioned, find that the results agree. The fact that this verification occupied about half an hour will show the great convenience of Cayley's tables.

It may be mentioned that an evident typographical error occurs on p. 377 of the tables (*Coll. Works*, vol. iii.), where the coefficient $\frac{765}{1024}$, in the first line of the second column, is printed $\frac{768}{1024}$. This error is corrected by means of the three coefficients immediately below in the same column.

Haverford College, Pa.:
1895 *February* 24.

Note on Professor Brown's Note. By E. J. Stone.

Professor Brown is quite right in saying that the terms

$$\sin(g+l)\left[+\tfrac{3}{8}\gamma^7\right] \text{ and } \sin(3g+3l)\left[-\tfrac{3}{8}\gamma^7\right]$$

which appear on p. 113 in my paper, "Expressions for the Elliptic Coordinates of a Moving Point to the Seventh Order of Small Quantities," are incorrectly printed.

The first is simply an error of sign. The second has arisen from the coefficient found for $\sin(g+l)$, $-\frac{3}{8}\gamma^7$, having been by inadvertence copied by me, when preparing the copy for press, into the argument for $\sin(3g+3l)$, instead of $-\frac{1}{8}\gamma^7$.

The coefficients of the terms $\sin(5g+5l)$ and $\sin(7g+7l)$, which involve γ^7, and were found conjointly with those above-mentioned, are correctly printed.

Radcliffe Observatory, Oxford:
1896 *March* 16.

On the Relative Efficiency of a Reflector and of Portrait Lenses for the Delineation of Celestial Objects. By Isaac Roberts, D.Sc., F.R.S.

It has often been asserted that portrait lenses have, by reason of their short foci and relative apertures, greater photographic power than instruments constructed on other models, such as a reflector; but the assertion had not been confirmed, on any occasion, within my experience in the past. I therefore considered it desirable to submit the question to the test of some crucial experiments; the results of which shall now be laid before the Society.

The experiments were conducted in the manner following.

Two typical portrait lenses were purchased, of the best quality that could be obtained, and were affixed with their cameras firmly to the tube of the 20-inch reflector. The arrangements were such that three photographs of the same objects, by three different instruments, could be taken simultaneously under precisely and in every respect similar conditions.

The photo-plates were of the same degree of sensitiveness, the durations of the exposures were quite equal, and the development of the negatives was similar in all cases.

The photo-negatives thus obtained were examined; the stars upon equal and coincident areas on each plate were counted, including the faintest stars that could, by aid of a magnifier, be recognised as true star-images. The nebulosity also was compared on each corresponding plate, together with its extent, area covered, density, details, and every distinctive feature noted.

A portrait lens of the latest pattern, and of the most rapid combination, was obtained from Dallmeyer and Co. The aperture is $3\frac{1}{2}$ inches, and stellar focus 9·56 inches. The ratio of aperture to focus is therefore 1 to 2·74, and it covers, without much distortion, a photo-field of about 11 degrees in diameter.

Messrs. Cooke and Sons made specially for me a Taylor's triplet combination lens of 5 inches aperture and 19·22 inches stellar focus. The ratio of aperture to focus is therefore 1 to 3·84, and for these experiments it was used as 1 to 4·8. It covers a photo-field, without much distortion, of about 15 degrees in diameter. My experience of this lens is most satisfactory, and I think it will be difficult to improve upon it.

The reflector has an aperture of 20 inches, focus 98 inches, ratio of aperture to focus 1 to 4·9, and the photo-field is about $2\frac{1}{2}$ degrees in diameter.

The two lenses referred to were affixed, as already stated, upon the tube of the 20-inch reflector, so that a photograph with the $3\frac{1}{2}$-inch, the 5-inch, and the 20-inch instruments could be taken simultaneously, and under all the conditions of equality essential to a full and fair trial.

The results of the experiments may now be given, but in order to obviate too much repetition, I will give only three typical examples and illustrations, for they will be representative of the whole series.

We will first project on the screen a photograph of the region of M. 33 *Trianguli*, which was taken on November 14 last with the Dallmeyer $3\frac{1}{2}$-inch lens, and exposure of the plate during two hours and fifteen minutes. The circular photo-field shown is 11 degrees in diameter, and therefore contains 95 square degrees. In the centre of the circle are ruled four lines which enclose a rectangular space of four square degrees, and upon this area I counted 380 stars; and if we assume the stars to be equally numerous all over the field of 95 degrees there would be 9,025 stars upon it. The star-discs are round, sharply defined, and the faint ones small; the nebula is shown as a small patch or stain on the film, with very little detail and very few stars involved in it, and the plate all over is considerably fogged.

The next photograph, shown on the screen, was taken simultaneously with that just described, with the Cooke 5-inch lens. The circular field is 11 degrees in diameter, and represents 95 square degrees of the sky, which are coincident with those on the first photograph, and the four ruled lines also enclose identically the same area of four square degrees. Upon this area I counted 840 stars, and on the assumption of equal stars on equal

areas there would be 19,950 stars on the 95 degrees. The stars are round, sharply defined, and the faint ones small; a considerable extent of the spiral nebula is shown together with structural details and many of the faint and bright stars which are involved; the plate is free from any trace of fogging.

The third photograph, now shown, was taken with the 20-inch reflector simultaneously with the two already described, and it will be observed that the scale is large because of the larger instrument used. The area of the sky represented is only four square degrees, and is coincident with the areas that were shown on the first and second photographs, enclosed within the four lines referred to. I counted upon these four degrees 2,960 stars, and by the assumptions made and applied to the other two photographs there would be 70,300 stars on 95 square degrees. The nebula was described and illustrated before the Society at the meeting in December last, and I need not here repeat the description then given; suffice it to state that we have had projected upon the screen, and made evident to sight, demonstrations of the fact that on the reflector photograph the nebula is more extensively and clearly depicted, that it is at least two stellar magnitudes denser, and that far more of the structural details are shown than can be seen on the photographs taken with the portrait lenses.

The stars also are 3·52 times more numerous on the reflector photograph than on that by the 5-inch lens, and 7·78 times more numerous than on the photograph by the $3\frac{1}{2}$-inch lens.

The examination of the nebulosity and the counting of the stars was in each of these cases done upon the original negatives.

The second series of the tests consists of three photographs of the region of γ *Cassiopeiæ*, which were taken simultaneously on 1895 December 13, with an exposure of the plates during two hours and twelve minutes.

The first, now exhibited, was taken with the Dallmeyer $3\frac{1}{2}$-inch lens. The circular photo-field is 11 degrees in diameter, and therefore contains 95 square degrees. Upon an area of four square degrees with γ in the centre I counted 1,080 stars; and assuming, as in the other cases cited, that the stars are distributed equally over the plate, there would be 25,650 stars on 95 degrees. The photo-diameter of γ measures 18·7 minutes of arc, and the two fan-like nebulæ on the *north following* side are faintly shown but without structural details; the plate is fogged in irregular patches that might be easily mistaken for nebulosity.

The second photograph was taken with the Cooke 5-inch lens, and the circular field is 11 degrees in diameter, and represents 95 square degrees of the sky coincident with the first. Upon an area of four square degrees, corresponding with that on the first photograph, I counted 2,610 stars; and under the conditions already named there would be 61,987 stars on 95 degrees. The photo-diameter of γ measures 10·23 minutes of arc, and the two fan-like nebulæ, already referred to, are much more prominently

shown, together with some structural details and many of the involved stars ; the plate is quite free from fogging effects and from spurious nebulosity.

The third photograph of this series is now shown ; it was taken with the 20-inch reflector simultaneously and under precisely the same conditions as the first and second photographs just described ; the photo-field is four degrees square, and upon this area I counted 17,100 stars ; and again assuming equal stars on equal areas there would be 406,125 stars on 95 degrees. The photo-diameter of γ measures 16′·9 of arc ; and the two fan-like nebulæ are very strongly and clearly shown with much structural detail ; lights and shade ; and lines and curves of stars involved making altogether not only a picture, but perpetuating each structural form, on a scale sufficiently large, for future scientific investigations and for the detection of any changes that must, some time or other, affect the character of the objects.

The stars are 6·55 times more numerous on the reflector photograph than on that by the 5-inch lens ; and 15·93 times more numerous than by the $3\frac{1}{2}$-inch lens.

The examination of the nebulosity, and the counting of the stars was, in this and in the third series of tests, made upon the positive copies here exhibited, and not upon the negatives, for the reasons which will presently be given.

I may here state that the two fan-like nebulæ, which have been referred to, were faintly shown on a photograph of the region of γ which was taken with the 20-inch reflector on 1890 January 17, but at that time I thought they were due to stains on the film. The photo-plates were, in those days, less sensitive than they are now made.

The third series of the tests consists of three photographs of the region of the *Pleiades* which were taken simultaneously on 1896 February 4, with an exposure of the plates during two hours and fifty minutes.

The first, now exhibited, was taken with the Dallmeyer $3\frac{1}{2}$-inch lens ; the circular photo-field is 11 degrees in diameter and contains 95 square degrees. Upon the area of four square degrees with η in the centre I counted 383 stars ; and assuming, as in all the other cases cited, that the stars are distributed equally over the plate, there would be 9,100 stars on 95 degrees. The nebula round *Merope* is shown, but without any structural details and none of the other well-known nebulosities in the group can be seen. The disks of the bright stars are large and fuzzy, and the plate is much fogged.

The second photograph, now shown, was taken with the Cooke 5-inch lens ; the circular field being 11 degrees in diameter and exhibiting 95 square degrees of the sky coincident with the first. Upon the area of four square degrees corresponding with that on the first photograph, I counted 953 stars ; and upon 95 degrees there would be 22,600 stars. The *Merope* nebula is well shown and with some detail ; so also are the other prominent

nebulosities in the group, and the plate is free from halation effects and fog. There is no indication of other nebulosity on other parts of the 95 degrees.

The last photograph of the series was taken with the 20-inch reflector, simultaneously with the two just described, and it exhibits four square degrees upon which I counted 3,470 stars; and upon 95 degrees there would be 82,400 stars. The stars are slightly elongated, but all the now known nebulosities are densely and brightly shown; crowded with details and free from halation and fog.

The stars are 3·64 times more numerous on the reflector photograph than on that by the 5-inch lens; and 9·06 times more numerous than by the $3\frac{1}{2}$-inch lens.

In all the experiments which I have made, the nebulosity, shown on the plates taken with the reflector, is denser than that by the portrait lenses in the ratio, approximately, of the relative number of faint stars shown on the plates which have been simultaneously exposed in the three instruments; and the illustrations which have been exhibited are proofs of the justness of this inference.

The results of the experiments herein described prove conclusively the greater efficiency of the reflector form of instrument over the portrait-lens or refractor form, for certain work in celestial photography; and it is not probable that refractors having shorter foci to apertures than 1 to 2·74 and 1 to 4·8, such as were used in these experiments, can, with greater perfection, be made of 20 inches aperture and 98 inches focus, so as to give better comparative results than those herein recorded.

These experiments also point to a practical limit of aperture to focus in the construction of instruments for celestial photography; and that the limit lies very nearly as 1 to 5; for I have consistently found a deterioration in the stellar images below aperture of 1 to 4; and apertures above 1 to 6 are slower in photographic effect.

Much misapprehension exists concerning the stellar image as seen in a telescope, and the photo-image as seen on a plate; it arises from the confusion of the ideas of points and surfaces of light. The telescopic image may be a point, but the photo-image is a measurable surface of chemical effect, spread on the sensitised film; and partakes of the character of nebulæ of small dimensions. As such, they must be subject to a rule which is not applicable to the visual telescopic image.

It follows from this that it is not possible, as it has been asserted, that a photographic instrument of the portrait lens form can imprint on the film images of nebulæ that are fainter than the faintest star-images imprinted at the same time and under exactly similar conditions.

The deductions which I have so far made are based upon the performances of lenses of a high character; but the ordinary portrait lenses are largely affected with imperfections producing

what are known as ghosts, and flares, in addition to fogging; therefore those who engage in stellar photography should first satisfy themselves that their lenses are free from these defects, and, above all, be careful that their plates are efficiently backed with some substance that will prevent reflections of the light from bright stars causing nebulous circles of halation on the film.

As illustrations of some of these defects, and also in further confirmation of the reliability of the results already given respecting the reflector and the portrait lenses, I will refer to some photo-positives on glass which are to be seen in the Library of the Society. They were taken by Professor Barnard at the Lick Observatory with what is described as the "Willard" lens, which has an aperture of 6 inches, and focus of 30·82 inches; the ratio of aperture to focus is therefore 1 to 5·14.

I shall refer only to three of these photographs, which are typical of the whole series. (1) The region of γ *Cassiopeiæ* was photographed on 1894 February 2, with an exposure of the plate during three hours; the photo-field is about $13\frac{1}{2}$ degrees in diameter, of which about 11 degrees are fairly free from distortion. γ is seen in the middle of a halation circle of about 28 minutes of arc in diameter; and the two fan-like nebulæ are shown, but with little if any structural details and only a few of the involved stars are visible. I counted 1,300 stars on 2° by 2° with γ in the centre, and this area coincides with the respective areas of four square degrees which have already been described and illustrated, when referring to the photographs taken with the two lenses and the reflector.

The results of the comparison of this photograph with the others are as follows:—

$3\frac{1}{2}$-inch lens; focus 2·74; exposure 132 minutes; 1,080 stars on 2° by 2°; the two nebulæ are visible but without structural details.

5-inch lens; focus 4·8; exposure 132 minutes; 2,610 stars on 2° by 2°; the nebulæ are well shown and some of the involved stars also.

6-inch Willard lens; focus 5·4; exposure 180 minutes; 1,300 stars on 2° by 2°; the two nebulæ are shown with some of the stars involved in them, but with less density and clearness than by the 5-inch lens.

20-inch reflector; focus 4·9; exposure 132 minutes; 17,100 stars on 2° by 2°; the two nebulæ are brilliantly shown, with structural details, and many stars both bright and faint involved in the nebulosity.

The other two photographs to which I shall refer are of the region of the *Pleiades*, taken with the Willard lens: one with an exposure of 4 hours on 1893 December 1, and the other with an exposure of $10\frac{1}{2}$ hours on 1893 December 6–8.

That with 4 hours' exposure shows the *Merope* nebula, but without any structural details; and there is a part of the projecting nebula from *Electra*; but all the rest of the nebulosity in

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the group is lost in the halation circles which surround each of the bright stars, and none of the distant nebulosity is shown. I counted on four square degrees, with η in the centre, 825 stars as against 953 on the 5-inch lens plate, and 3,470 stars on the reflector plate; the exposure of the two last named being $2^h\ 50^m$ against 4^h with the Willard lens.

The plate exposed during $10\frac{1}{2}$ hours shows only 1,385 stars on $2°$ by $2°$, whilst the same area on the 4^h plate has 1,259 stars; therefore the difference in photo-effect upon the two plates is less than that of one stellar magnitude. This fact throws some doubt upon the reality of the distant nebulosity which is shown on the plate; and when we consider that the whole patch, that covers the group of the *Pleiades*, is due to halation, and not to nebulosity, the doubt is further strengthened.

The star images on this photograph are double and overlap; the exposures of the plate, therefore, were effectively of less than $10\frac{1}{2}$ hours' duration.

Photograph of the "Owl" Nebula M 97 and of the Nebula H V 46 *Ursæ Majoris.* By Isaac Roberts, D.Sc., F.R.S.

The photograph of the nebula M 97, R.A. $11^h\ 8^m\ 42^s$, Decl. 55° 36′ (epoch 1895), and of H V 46, R.A. $11^h\ 5^m\ 22^s$, Decl. 56° 15′ north, was taken with the 20-inch reflector on 1895 April 20, with an exposure of the plate during four hours, and the copy now presented is enlarged to the scale of 1 millimetre to 15 seconds of arc.

The nebula M 97 is N.G.C. No. 3587, G.C. No. 2343, *h* 838. Rosse, *Obs. of Neb. and Cl. of Stars*, p. 93, and *Phil. Trans.* 1850, Pl. XXXVII. fig. 11.

Sir J. Herschel (G.C. 2343) describes it as a very remarkable object, a planetary nebula, very bright, very large, round, very, very gradually, then very suddenly brighter in the middle, $19^s{\cdot}0$ in diameter. It is figured in the *Phil. Trans.* 1833 as a circle, stippled without any details.

Lord Rosse (cited above), in 1850, figured the nebula as a circle filled in with details somewhat resembling the face of an owl, with hair-like projections round the margin; and between the years 1848 and 1874 records the particulars of forty-five observations which were made. In some of them both he and Dr. Robinson saw a faint star to the right of the central star, and suspected the existence of one or two other very faint stars, as well as a spiral shape, but he does not refer to the hair-like surroundings of the nebula.

The photograph, now projected on the screen, shows the nebula as an ellipse with the major axis in *north following* to *south preceding* direction: it measures about 203 seconds of arc

in length. The star in the centre is very conspicuous, and of about 15th magnitude ; but there is no other star anywhere in the nebula, though there are two very faint condensations of nebulosity near the *north preceding* margin. The nebula seems as if it consisted of two nebulous disks superposed : the first a complete circular plane of faint nebulosity upon which is superposed a broad ring of dense nebulosity of lesser diameter than the plane and leaving uncovered an elliptical space, in the centre, in the middle of which is placed the star already referred to.

The ring is not of equal breadth all round, but is widened on the *north following* and *south preceding* sides, and narrowed on the *south following* and *north preceding* sides ; there is an absence of structure in the nebulosity, and the photograph does not indicate any nebulous projections beyond the symmetrical outline of the nebula. The disappearance of the second star, seen both by Lord Rosse and Dr. Robinson, is remarkable.

Photograph of the Nebula H V 46 *Ursæ Majoris.*
By Isaac Roberts, D.Sc., F.R.S.

The photograph of the nebula H V 46 *Ursæ Majoris*, R.A. $11^h\ 5^m\ 22^s$, Decl. 56° 15′ north, was taken with the 20-inch reflector on 1895 April 20, with exposure of the plate during four hours, and the copy now presented is enlarged to the scale of 1 millimetre to 15 seconds of arc.

The nebula is N.G.C. No. 3556, G.C. No. 2318, *h* 831. Rosse, *Obs. of Neb. and Cl. of Stars*, pp. 92, 93.

Sir J. Herschel (G.C. 2318) describes the nebula as considerably bright, very large, very much extended in the direction 79°, pretty bright in the middle, resolvable.

Lord Rosse records seven observations made between 1850 and 1874, and calls it a curiously twisted nebula, a large faint and much mottled ray with three stars involved ; numerous stars involved ; but much uncertainty in his observations is frequently indicated.

The photograph, as will be seen on the slide now projected on the screen, shows the nebula as an ellipse viewed at an acute angle with its plane, the major axis being in the direction of *preceding* and *following* at an angle of 79°, as stated. Four well-defined stars of 14th to 16th magnitude are involved in the nebulosity, and, besides, there are six star-like condensations involved ; the nebulosity which forms the rings is much broken up into masses, and the nebula seems to be one of the class in which we might expect, within a comparatively short period, to detect changes taking place in its structure.

Photograph of the Cluster H VII 66, *and of the Nebula* H IV 75 *Cephei.* By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster H VII 66 *Cephei*, R.A. $21^h\ 43^m\ 24^s$, Decl. 65° 17′ north, was taken with the 20-inch reflector on 1895 September 25, with an exposure of the plate during three hours, and the copy now presented is enlarged to the scale of 1 millimetre to 24 seconds of arc.

The cluster is N.G.C. No. 7142, G.C. No. 4709, *h* 2134. Rosse, *Obs. of Neb. and Cl. of Stars*, p. 163.

It is described by Sir J. Herschel (G.C. 4709) as considerably large, considerably rich, pretty compressed, stars 11th to 14th magnitude.

The photograph is in agreement with the general descriptions given, and, in addition, shows each star in the cluster in true relative position and magnitude down to about the 17th. The chief use of the photograph will be as a reliable record for future comparison of the stars in the cluster and in the surrounding region of the sky.

Photograph of the Nebula H IV 75 *Cephei.*

The photograph of the nebula H IV 75 *Cephei*, R.A. $21^h\ 40^m\ 34^s$, Decl. 65° 37′ north (epoch 1895), was taken with the 20-inch reflector on 1895 September 25, with exposure of the plate during three hours, and the copy now presented is enlarged to the scale of 1 millimetre to 24 seconds of arc.

The nebula is N.G.C. No. 7129, G.C. No. 4702, *h* 2131. Rosse, *Obs. of Neb. and Cl. of Stars*, p. 162.

Sir J. Herschel (G.C. 4702) describes the nebula as a remarkable object, considerably faint, pretty large, gradually brighter in the middle, with three stars involved.

The photograph shows the nebula to be elliptical, measuring 432″ in *north following* to *south preceding* direction, and 285″ in *south following* to *north preceding*. The nebulosity is dense on the *north following* side, and involved in it, as a nucleus, are the three stars referred to by Sir J. Herschel: two of them are of about 12th magnitude and the third 16th magnitude. There are also eleven other stars, ranging between the 12th and 17th magnitudes, apparently involved in the nebula. The character of the nebulosity is flocculent with extensive dark areas, but there is some structure visible near the *north following* margin.

There are three stars, each of about 13th magnitude, surrounded by very faint nebulosity in the positions following, measured from the centre of the tristellar nucleus of the nebula: (1) 358″ *north following*; (2) 326″ *north preceding*; (3) 277″ *north preceding*. The stars Nos. 2 and 3 are not referred to in Dr. Dreyer's catalogues, and the measurements given above are approximate.

Observations of the Variable Stars W, X, and Y Sagittarii.
By Lieut.-Colonel E. E. Markwick.

The following observations were made at Gibraltar with a binocular field-glass magnifying about five times, and are in continuation of those appearing at p. 338 vol. lv. of the *Monthly Notices.*

W Sagittarii. Thirty-five observations, the star being compared with 14 (U.A.) *Sagittarii*, 5·4 mag. In the table, the first column gives the date of observation for identification. The second is the day and hour of observation reduced to G.M.T., and converted into Julian days and fraction. The next column is the observed magnitude. Maxima were calculated from Dr. Chandler's formula—viz.

1866 Sept. 4 = 240 2849·45 + 7·59460 E.

With the other data in Chandler's second catalogue—viz. variation 4·8 to 5·8 and $M-m=3\cdot00\ d$—a typical curve was drawn (see *Monthly Notices*, vol. liv. p. 138), and the observations plotted on the same scale. The distance of each observation from the curve horizontally was then measured off in fractions of a day, those to the left of the curve being negative, and *vice versa.*

The fourth column gives the interval in days elapsed between date of observation and next preceding maximum. The last column gives the distances just referred to. Remarks from observing book are added.

W Sagittarii.

Date. 1895.	Julian 2,410,000 + *d*	Observed brightness.	After maximum. *d*	O−C. *d*
July 13	3388·42	5·6	5·26	−0·3
14	89·44	5·4	6·28	+0·4
15	90·42	4·95	7·26	+0·4
17	92·39	4·9	1·64	+0·9
17	92·44	5·0	1·69	+0·5
18	93·46	5·25	2·71	+0·6
19	94·44	5 5	3·69	+0·9
20	95·45	5·8	4·70	+0·2
21	96·41	5·7	5·66	+0·5
22	97·38	4·7	6·63	−1·0
22	3397·43	5·0	6·68	−0·1
26	3401·39	5·45	3·04	+0·4
27	02·43	5·6	4·08	+0·8
30	05·38	4·8	7·03	−0·5
Aug. 7	3413·35	4·6	7·41	−0·2

Date. 1895.	Julian 2,410,000*d* + *d*	Observed brightness.	After maximum. *d*	O−C. *d*	
Aug. 11	3417·43	5·6	3·89	+0·7	
12	18·38	5·5	4·84	−0·9	
12	18·40	5·6	4·86	−0·6	
16	22·43	5·3	1·30	−0·9	
17	23·43	5·3	2·30	+0·1	
24	30·42	5·1	1·69	0 0	
Sept. 8	45·33	5·2	1·41	−0·5	
9	46·38	5·6	2·46	−0·8	Clouds about.
29	66·32	4·8	7·21	−0·4	Moon.
Oct. 4	71·30	5·5	4·60	−1·1	Twilight.
7	74·30	5·1	0·01	−1·6	
9	76·30	5·3	2·01	−0·2	
10	77·32	5·4	3·03	+0·5	
11	78·32	5·7	4·03	+0·4	
14	81·31	4·9	7 02	0·0	
16	83·29	5·3	1·40	−0·8	
18	85·32	5·8	3·43	−1·0	
30	3497·27	4·9	0·19	−0·5	Bright moonlight.
Nov. 2	3500·28	5·2	3·20	+1·2	Twilight and Moon.
3	3501·28	5·5	4·20	+1·4	

From the last column we get as the sum of 16 positive residuals 9·9 days, and of 17 negatives 11·4 days. Combining these with the observations of 1893 and 1894, we get the following result:

	No. of Observations		Sum of	
	with Positive Residuals.	with Negative Residuals.	Positive Residuals. *d*	Negative Residuals. *d*
1893	16	22	10·0	14·5
1894	10	14	5·1	12·5
1895	16	17	9·9	11·4
Total	42	53	25·0	38·4

We therefore get 0·60 day as the average value of a positive, and 0·72 day as the average value of a negative residual. On the whole, it seems that the period of 7·59460 days is correct, and the star's variation conforms very regularly to it.

X Sagittarii. Thirty-four observations, treated as in the previous case. Comparison star F 4 *Sagittarii* 5·4 *m.* Chandler's data for this star are—

Elements of maximum 1870 Aug. 16 = 240 4291·78 + 7·01185 E.

Variation 4 to 6. M − *m* = 2·876*d*.

X Sagittarii.

Date. 1895.	Julian 2,410,000*d*+ *d*	Observed brightness.	After maximum. *d*	O−C. *d*	
July 13	3388·42	5·4	2·27	−0·5	
14	89·44	5·7	3·29	0·0	
15	90·42	5·8	4·27	+0·8	
17	92·39	4·5	6·24	−0·7	
17	92·44	4·9	6·29	−0·1	
18	93·46	4·9	0·30	−1·2	
19	94·44	5·1	1·28	−0·8	
20	95·45	5·35	2·29	−0·4	Careful estimate.
21	96·41	5·7	3·25	0·0	
22	97·38	5·6	4·22	+1·2	"Bilious!"
22	3397·43	5·7	4·27	+1·0	
26	3401·39	5·0	1·22	−0·5	Moon.
27	02·43	5·2	2·26	0·0	
30	05·38	5·7	5·21	−0·3	Moon.
Aug. 7	13·35	5·7	6·17	+0·7	
11	17·43	5·1	3·24	+1·2	
12	18·38	5·6	4·19	+1·2	
12	18·40	5·7	4·21	+1·0	
16	22·43	4·7	0·23	−0·4	
17	23·43	5·1	2·23	+0·2	
24	30·42	5·5	2·20	−0·7	
Sept. 8	45·33	5·2	3·09	+0·8	
9	46·38	5·95	4·14	−0·1	Clouds about.
29	66·32	5·6	3·05	0·0	Moon.
Oct. 4	71·30	5·2	1·01	−1·3	
7	74·30	5·4	4·01	+1·3	
9	76·30	5·0	6·01	−0·2	
10	77·32	4·8	0·02	−1·1	
11	78·32	5·0	1·02	−0·7	
14	81·31	5·7	4·01	+0·7	Levanter wind.
16	83·29	5·4	5·99	+0·2	
30	3497·27	5·6	5·94	+0·3	Bright moonlight.
Nov. 2	3500·28	5·4	1·94	−0·8	Observation difficult. Moon and twilight.
3	01·28	5·9	2·94	−1·1	

From the last column we get as the sum of 13 positive residuals 10·6 days, and of 17 negative 10·9 days. Combining

these with the observations of 1893 and 1894, we get the following :

	No. of Observations with Positive Residuals.	No. of Observations with Negative Residuals.	Sum of Positive Residuals.	Sum of Negative Residuals.
1893	25	14	7·2	22·8
1894	5	16	1·8	16 2
1895	13	17	10·6	10·9
Total	43	47	19·6	49·9

Hence for the three years

Average value of a positive residual = 0·46 day

„ „ negative „ = 1·06 day

The observations for 1895 cluster closely round the typical curve, and support it better than those of the two preceding years. In fact, if the most probable curve were drawn among the 1895 observations, independently, I think that such curve would be found to approximate very closely to the pattern light curve. Hence no correction to the period given above seems required.

Y Sagittarii. Compared with 45 (U.A.) of *Sagittarius*, 6·5*m*, 26 observations in 1894, 41 in 1895. Those for 1893 are in vol. xiii. p. 180 of the *Astronomical Journal*. They are treated as before, the data being

1886 Sept. 25 = 241 0175·02 + 5·7732 E.

Variation 5·7 to 7·0. M − *m* = 1·80*d*.

Y Sagittarii.

Date. 1894.	Julian 2 410 000*d* + *d*	Observed brightness.	After maximum. *d*	O−C. *d*	
Aug. 20	3061·41	5·8	5·56	+0·1	
25	66·39	6·6	4·77	+1·0	
26	67·39	6·2	0·00	+0·9	
27	68·33	6·2	0·94	−1·1	Twilight.
27	68·37	6·4	0·98	−1·4	
28	69·38	6·5	1·99	−0·5	
Sept. 4	76·39	6·6	3·22	+0·6	
20	92·38	6·7	1·89	−0 9	Clouds about.
21	93·33	6·8	2·84	−0·3	
22	94·32	6·6	3·83	−0·8	
22	94·38	6·75	3·89	−0·5	
25	97·32	6·55	1·06	−1·4	
25	97·37	6·7	1·11	−1·8	

Date. 1894.	Julian 2,410,000*d* + *d*	Observed brightness.	After maximum. *d*	O−C. *d*	
Sept. 26	3098·31	6·8	2·05	−1·0	
29	3101·31	6·6	5·05	+0·5	
Oct. 1	03·31	6·7	1·28	−1·6	
2	04·32	6·7	2·29	−0·6	
4	06·31	6·9	4·28	−0·1	
4	06·37	6·8	4·34	−0·1	
21	23·30	7·0	3·95	0·0	
22	24·28	6·4	4·93	+0·2	
24	26·31	6·5	1·18	−1·4	
27	29·30	6·8	4·17	−0·3	
29	31·31	6·3	0·41	−1·6	
31	33·30	6·7	2·40	−0·5	
Nov. 16	3149·27	6·3	1·05	−1·1	Bright twilight.
1895.					
July 13	3388·41	6·15	3·49	−1·5	
14	89·44	6·1	4·52	−0·6	
15	90·43	5·75	5·51	−0·1	
17	92·39	5·9	1·70	+0·7	
17	92·44	6·1	1·75	+0·1	
18	93·47	6·5	2·78	+0·3	
19	94·44	6·7	3·75	−0·8	
20	95·45	6·5	4·76	0·0	
21	96·41	5·7	5·72	0·0	
22	97·38	5·5	0·98	+1·0	
22	97·43	5·9	0·96	−0·1	
26	3401·43	6·2	4·96	0·0	
27	02·43	5·9	0·19	−0·9	
30	05·38	6·4	3·14	+0·9	Moon.
Aug. 7	13·35	5·8	5·34	−0·1	
11	17·43	6·4	3·65	−1·2	
12	18·38	6·6	4·60	−0·1	
12	18·40	6·5	4·62	−0·1	
16	22·43	6·3	2·87	+0·7	
17	23·42	6·45	3·86	−1·0	
24	30·41	6·6	5·08	+0·5	
Sept. 9	46·38	6·6	3·73	+1·0	Clouds about.
29	66·28	6·1	0·54	−1·1	Moon.
Oct. 4	71·30	6·0	5·56	+0·4	

Date. 1894.	Julian 2,410,000d+ d	Observed brightness.	After maximum. d	O−C. d	
Oct. 7	3474·31	6·7	2·80	0·0	
9	76·30	6·6	4·79	+0·1	
10	77·31	6·3	0·02	−2·1	
11	78·32	6·3	1·03	−1·1	
14	81·31	6·8	4·02	−0·5	
16	83·29	6·2	0·23	−1·6	
18	85·32	6·7	2·26	−0·6	
27	94·31	6·2	5·47	+0·5	Doubtful observation.
30	3497·27	6·7	2·66	−0·2	
Nov. 2	3500·28	6·22	5·67	+0·7	
3	01·28	6·2	0·90	−1·1	
5	03·29	6·5	2·91	+0·4	
7	05·30	6·5	4·92	+0·2	Clouds about.
8	06·28	6·0	0·02	−1·3	Clouds about.
12	10·27	6·8	4·11	−0·3	
13	11·30	6·6	5·14	+0·4	Getting very low.
16	3514·28	6·7	2·36	−0·5	

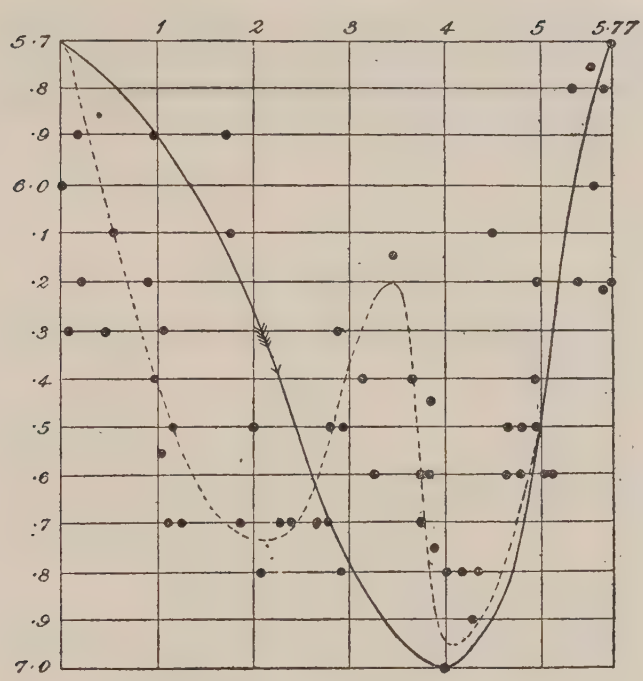
	No. of Observations		Sum of	
	with Positive Residuals.	with Negative Residuals.	Positive Residuals.	Negative Residuals.
1893	22	19	9·7	9·0
1894	19	6	3·3	17·1
1895	22	15	7·9	16·9
Total	63	40	20·9	43·0

Therefore for the three years

Average value of positive residual = 0·33d.

" " negative " = 1·07d.

I attach a drawing of the 1894–95 observations plotted to scale. In several cases the dots fall twice on the same place. An inspection shows that many of the observations cluster very closely round the rising branch, while in the descending branch the dots seem to be more scattered. On the whole, I do not think that for the present any further approach to accuracy could be gained by an alteration of the period. If lengthened or shortened the typical curve would be shifted either to the right or left, and it is plain that either of these movements, although bringing the curve into closer proximity to *some* dots, would yet leave others at a further distance from it. The same argu-



ment applies to a possible systematic error in estimating the star's brightness. In this case the typical curve must go either up or down vertically. Neither of such movements would on the whole, I think, bring it into any better relation to the dots. Neither would a better correspondence be produced by shifting the minimum phase —*i.e.* altering M—*m*. Therefore the adopted period would seem correct.

If, however, in future years the negative residuals go on increasing, it will be necessary to consider a slight diminution of the period.

It is just possible that a secondary maximum is indicated, occurring about 3·3 days after the principal one. I have shown this by a dotted line. Although I am diffident as to the objective reality of the supposed phenomenon, I place it on record here. The observations of future years will settle the question.

The three stars which have been dealt with all appear to belong to the same class, *S* 10 *Sagittæ* being a representative in the northern hemisphere. It is difficult to account for variation of this nature. Whether it be due to eclipses by one or more opaque attendants, to unequal brilliancy of successive portions of the visible disk as presented to the Earth at time of observa-

tion, or to changes in the brilliancy of the star's photosphere—whatever it be due to—the remarkable regularity with which the light waxes and wanes must be always taken into account in the theory, at once differentiating this class from the long-period variables which are subject to great irregularities in their periods.

Gibraltar: 1896 *February* 3.

Melbourne Observatory.

The following letter and report were received by the Secretaries on April 13, too late for inclusion in the Annual Report of the Council :—

"*Observatory, Me'bourne:*
"1896 *March* 10.

"DEAR SIR,—I am sending you herewith a Report of our work in 1895. The very long delay was unavoidably caused by my absence from the Observatory.

"Believe me, very truly yours,
"PIETRO BARACCHI.

The Secretary, Royal Astr. Society, London."

The following is a brief account of the work carried out at the Melbourne Observatory during the year 1895 :—

Meridian Work.—Observations in Right Ascension 2,503, in North Polar distance 1,387, subdivided as follows: viz. 819 observations of standard clock stars, 255 of azimuth stars, 54 special stars observed three times in both coordinates for the Adelaide Observatory, and the remainder, observations of stars for use in connection with our astrophotographic work. With regard to the latter stars it may be stated here that they were taken from a list, which we are gradually completing, consisting of stars selected from the catalogue plates in the zone allotted to this observatory (five stars in each plate suitably distributed for the purpose of facilitating the final reduction of these plates), and intended for observation with the transit circle. 195 of these stars have also been observed at the Adelaide Observatory and Sir Charles Todd has promised further help in this direction. The transit circle was reversed in 1895 March.

Astrophotographic Work.—Number of exposed plates 397, subdivided as follows : viz. catalogue plates 236, chart plates 49, Oxford type charts 26. Plates exposed on the pole for testing the clearness of the night 53, plates for trails 22, for adjustment of the centre 11. Of these 17 were rejected on account of defects in the film, setting, or broken exposure. Each plate was submitted to a preliminary examination in order to ascertain that the general conditions, such as accurate setting, orientation,

intensity of images of minimum magnitude stars, definition, &c., were satisfactory ; and also for the selection and measurement of the five stars mentioned above. These measurements are made by a micrometer scale (of the type proposed by Professor Turner) made by Troughton and Simms. It works satisfactorily in so far at least as these preliminary measures are concerned. Only 139 plates remain to be taken in the zone allotted to Melbourne, and these will be secured in the course of this year.

Time Service.—On 1895 February 1, zone time referred to the meridian 10^h east of Greenwich was inaugurated in the Colony of Victoria, and accordingly since then the time-ball has been caused to drop $20^m\ 6^s$ earlier than formerly. Zone time signals were transmitted to town and up-country telegraph and railway stations as usual.

Magnetical.—The photographic curves representing the variation of the elements of terrestrial magnetism have been secured throughout the year with only a few hours of accidental interruption. Absolute measurements were made about once a month.

Meteorological Service.—Two forecasts of the weather were issued daily. Rainfall statistics and weather records have been prepared for the press in quarterly publications as in preceding years. Photographs of the Sun were taken on 58 days.

Miscellaneous.—Testing of nautical, surveying, and meteorological instruments, and rating of chronometers for the public. This formed part of our routine work throughout the year. 350 visitors were attended to on Wednesday afternoons, and 247 were admitted at night to view the moon, &c. through the great telescope.

General Remarks.—In March last Mr. E. F. J. Love, M.A., Lecturer on Physics at the Melbourne University, returned to Melbourne after a visit to England, during which he swung the three half-second pendulums of this observatory at Greenwich, Kew, and Cambridge, for gravity determinations. It was necessary to again swing these pendulums after the voyage in order to ascertain their invariability. This was done, and from a preliminary reduction of my observations made here before and after Mr. Love's trip to England, it appears that no appreciable change took place in the instruments. Mr. Love is now engaged in making a fresh determination of the pressure and temperature corrections, after which the final reductions will be made and the results published.

Very few observations were made with the great telescope and smaller equatorial. The examination of the southern nebulæ, for which the great telescope is almost solely adapted (apart from celestial photography), was suspended in 1892, owing to reorganisation of the staff, necessitated by the retirement of the first and second assistants, Messrs. White and Moerlin. The work had been in my charge for the previous eight years, and at the end of that time many hundreds of drawings, sketches, and descriptions of nebulæ, with micrometric measurements of neighbouring

stars were added to those of previous observers. These were intended to be arranged in proper form and reduced for publication as a sequence to part I. of *Observations of Southern Nebulæ, &c.*, edited by Mr. Ellery, but circumstances prevented the carrying out of this purpose.

It would now seem undesirable, even if time could be spared for this most attractive class of astronomical observations, to continue the work on nebulæ, until we have dealt with the material already secured.

Other still unpublished works are the Melbourne zones 60° to 69° 20′ south declination, observed between 1866 and 1871, and the annual catalogues 1884–94 inclusive, all fully reduced.

In April last Mr. Fred Ingamells, one of the junior assistants who had given valuable services for 12 years, retired in pursuance of a retrenchment scheme proposed by the Government.

Mr. Ellery's voluntary retirement from the post of Government astronomer, which, as has already been notified, took place in July last, was a loss to the observatory which cannot be overrated, and will be felt for a long time. Thus in the last three years the staff has been severely weakened by the retirement of four workers, including its oldest and most experienced members and its director. It is, however, intended to keep the meridian and astrophotographic work up to the usual standard of past years.

The meteorological work which weighs so heavily on the time and energy of the institution can hardly be reduced, as the public demands it with increasing exigency.

The magnetic work cannot be discontinued, as this is the only station in Australia where such observations are systematically carried out. Indeed, there seems to be a revival of general interest in terrestrial magnetism with some prospect of concerted observations being undertaken, and no doubt the co-operation of this observatory, where records have been continuously taken for over 30 years, seems all the more desirable.

The investigation of the division errors of the 8″ transit circle has not yet been made. It is fully recognised that a catalogue based upon the observations made with this instrument since 1884 cannot be completed until such investigation is accomplished. The question of measurement and reduction of the astrophotographic plates has not yet been seriously considered. It is hoped that at the forthcoming conference of the International Committee to be held at Paris in May next, some understanding may be arrived at as to the course to be adopted for this purpose.

Note on Comet Perrine (1895 *IV*). By Dr. H. Kreutz.

(*Communicated by the Secretaries.*)

The following letter has been received from Dr. Kreutz :—

"*Kiel:* 1896 *April* 18.

"In *Monthly Notices*, 1896 March, theilt Herr H. C. Russell die Beobachtung eines Cometen von A. E. Parker d. d. 1895 Dec. 21–24, mit. Es ist nun gar kein Zweifel, dass es sich hier um eine Beobachtung des ersten Cometen Perrine handelt; vergl. die Mittheilung aus Dar-es-Salaam *Astr. Nachr.* 3339, p. 47, und *The Observatory*, 1896 Jan., p. 62."

Further Note on the Light seen at Oxford on 1896 *March* 4. By H. H. Turner, M.A., B.Sc., Savilian Professor.

In the letter above quoted Dr. Kreutz continues :—

"Eine ganz ähnliche Erscheinung, wie Sie am 4. März d. J. sahen, ist auch von uns vor längerer Zeit (1895 März 13) in Kiel in W.N.W. beobachtet worden. Hier aber konnte Prof. Lamp, der sich auf dem höchst gelegenen Punkt der Sternwarte befand, constatiren, dass es sich um einen Nordlichtstrahl handelte. Von unten aus gesehen, war die Erscheinung, welche circa $\frac{1}{4}$ Stunde andauerte, dem Schweife eines grossen Cometen täuschend ähnlich."

Mr. Charles Martin, Assistant at Dunsink, writes me as follows :—

"*Dunsink House, co. Dublin :*
"1896 *April* 19.

"I saw in *The Observatory* that you read a paper on zodiacal light seen by you on March 4. I was observing that night here, and watched the light for about two minutes. It was 5° wide, and stretched from the horizon to about 40° N.P.D. I only saw it for two minutes, as thick clouds came up and hid it. It was in the N.W. by W. I thought myself that it was clouds at a great distance above the other clouds, but could not make much out of it, as it clouded up soon after I noticed it. Time, 8.30 P.M., Irish time."

Observations of Comet a 1896 (*Perrine-Lamp*) *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power, 55.

Greenwich Mean Solar Time.	Observer.	✐ − ✱ R.A.	Corr. for Refraction.	Log Factor of Parallax.	✐ − ✱ N.P.D.	Corr. for Refraction.	Log Factor of Parallax.	No. of Comps.	Appt. R.A.	Appt. N.P.D.	Comp. Star.
1896. d h m s		m s	s		′ ″	″			h m s	° ′ ″	
Mar. 12 11 9 24	H.	+1 43·28	0·00	9 7094	+4 0·8	+0·2	0·7904	4	3 1 44·35	41 25 32·1	*a*
12 11 9 24	„	−1 40·67	−0·01	9·7094	+8 27·7	+0·4	0·7904	4	...	...	*b*
12 11 33 46	„	−3 55·29	−0·01	9·6867	+3 30·0	+0·2	0·8180	2	3 1 53·26	41 26 7·9	*c*
22 8 1 58	B.	−0 55·76	0·00	9·6684	−4 54·1	0·0	0·5007	3	...	...	*d*
22 8 2 37	„	−1 55·85	0·00	9·6690	+0 54·1	0·0	0·5021	4	3 49 39·99	45 9 0·4	*e*
23 8 42 25	„	+0 21·04	−0·01	9·6960	−5 35·1	0·0	0·5855	5	3 52 56·54	45 27 8·4	*f*
23 9 5 1	„	+0 24·24	0·00	9·7063	+3 44·2	0·0	0·6262	4	3 52 59·44	45 27 20·2	*g*
Apr. 1 8 55 5	A. C.	−1 55·00	0·00	9·6923	−2 10·5	0·0	0·6509	2	4 15 11·09	47 32 5·2	*h*
1 8 55 19	„	−2 8·77	0·00	9·6922	+1 14·8	0·0	0·6513	6	4 15 12·04	47 32 15·4	*k*

Notes.

The observations are corrected for refraction but not for parallax. They are also corrected for the error of inclination of the wires and for the motion of the comet.

March 12.—Observations rather uncertain. Comet getting low (zenith distance 68°), and much fainter.

March 22.—Comet extremely faint. Bright moonlight. Observations difficult and uncertain.

March 23.—Bright moonlight. Comet still fainter than on previous day. Only seen by glimpses.

April 1.—Comet still easily visible, but rather ill-defined.

The initials H., A C., B., are those of Mr. Hollis, Mr. Crommelin, and Mr. Bryant respectively.

LEEDS

Comparison Stars.

	Star's Name.	Assumed R.A. 1896·0.	Assumed N.P.D. 1896·0.	Authority.
		h m s	° ′ ″	
a	BD + 48°, No. 849	3 0 1·19	41 21 48·2	Bonn Astr. Gesell. Catalogue.
b	BD + 48°, No. 857	3 3 25	41 17	Bonn Observations, vol. v.
c	Lalande 5851	3 5 48·62	41 22 55·1	Bonn Astr. Gesell. Catalogue, Paris Catalogue 1875, and Annual Catalogue 1882.
d	BD + 44°, No. 819	3 50 36	45 14	Bonn Observations, vol. v.
e	BD + 44°, No. 822	3 51 35·56	45 8 22·8	Bonn Astr. Gesell. Catalogue.
f	BD + 44°, No. 828	3 52 35·23	45 32 59·7	,, ,, ,,
g	BD + 44°, No. 827	3 52 34·93	45 23 52·3	,, ,, ,,
h	BD + 42°, No. 952	4 17 5·72	47 34 30·9	,, ,, ,,
k	BD + 42°, No. 954	4 17 20·44	47 31 15·8	,, ,, ,,

Lalande 5851.—The R.A. of this star, in Paris Annual Catalogue for 1882, has been increased by 0ˢ·80 in accordance with a communication from M. Tisserand.

Royal Observatory, Greenwich:
1896 *April* 9.

Ephemeris for Physical Observations

Greenwich Noon.	P.	L−O.	B.	A−L.	*B.*	Q.	E.
1896.	°	°	°	°	°	°	°
May 20	332·98	95·542	−24·88	−42·90	−20·52	245·62	39·66
22	332·25	97·188	24·77	43·24	20·84	245·64	39·90
24	331·54	98·827	24·64	43·57	21·15	245·67	40·13
26	330·86	100·460	24·49	43·88	21·45	245·71	40·36
28	330·19	102·086	24·32	44·18	21·74	245·77	40·58
30	329·54	103·704	−24·14	−44·47	−22·03	245·84	40·80
June 1	328·92	105·313	23·94	44·74	22·30	245·93	41·01
3	328·32	106·914	23·72	45·00	22·56	246·03	41·22
5	327·74	108·507	23·49	45·25	22·81	246·15	41·43
7	327·19	110·090	23·24	45·48	23·04	246·28	41·64
9	326·66	111·662	−22·97	−45·69	−23·27	246·43	41·84
11	326·15	113·223	22·69	45·89	23·49	246·59	42·04
13	325·67	114·773	22·40	46·07	23·69	246·76	42·23
15	325·21	116·311	22·09	46·24	23·88	246·94	42·42
17	324·78	117·838	21·77	46·39	24·06	247·14	42·60
19	324·37	119·353	−21·44	−46·52	−24·22	247·35	42·78
21	323·99	120·856	21·09	46·64	24·37	247·58	42·95
23	323·63	122·346	20·73	46·75	24·51	247·82	43·12
25	323·30	123·823	20·36	46·84	24·64	248·06	43·28
27	323·00	124·288	19·98	49·92	24·76	248·32	43·44
29	322·72	126·740	−19·58	−46·98	−24·86	248·59	43·60
July 1	322·47	128·179	19·17	47·03	24·95	248·88	43·75
3	322·24	129·605	18·76	47·06	25·03	249·17	43·90
5	322·03	131·018	18·34	47·08	25·09	249·48	44·04
7	321·85	132·417	17·91	47·08	25·14	249·79	44·18
9	321·70	133·803	−17·47	−47·08	−25·18	250·12	44·31
11	321·57	135·175	17·03	47·06	25·20	250·46	44·43
13	321·46	136·533	16·58	47·03	25·21	250·81	44·55
15	321·38	137·877	16·12	46·98	25·21	251·16	44·66
17	321·32	139·207	15·65	46·92	25·20	251·53	44·77
19	321·29	140·523	−15·18	−46·86	−25·17	251·90	44·87
21	321·28	141·825	14·71	46·78	25·13	252·28	44·96
23	321·29	143·114	14·23	46·69	25·07	252·67	45·05

of Mars, 1896–97. By A. Marth.

Greenwich Noon. 1896.	Bright-ness.	Appar. Diam.	Defect of Illumination q Equat.	Polar.	Central Meridian. ω_0	Passage of Zero Meridian.	
	m	″	″	″	°	h m	h m
May 20	0·97	6·15	0·71	0·71	0·00	207·52	10 27	11 8
22	0·95	6·20	·72	·72	·00	187·68	11 49	12 29
24	0·94	6·24	·73	·73	·00	167·84	13 10	13 51
26	0·93	6·28	·75	·74	·00	148·01	14 32	15 13
28	0·92	6·32	·76	·75	·01	128·19	15 54	16 35
30	0·90	6·37	0·77	0·76	0·01	108·38	17 15	17 56
June 1	0·89	6·41	·79	·77	·01	88·58	18 36	19 17
3	0·88	6·45	·80	·78	·01	68·78	19 58	20 38
5	0·87	6·50	·81	·79	·02	48·99	21 19	22 0
7	0·86	6·55	·83	·80	·02	29·21	22 40	23 21
9	0·84	6·59	0·84	0·81	0·02	9·45	...	0 2
11	0·83	6·64	·85	·82	·02	349·69	0 42	1 23
13	0·82	6·69	·87	·83	·03	329·94	2 4	2 44
15	0·80	6·73	·88	·84	·03	310·21	3 25	4 5
17	0·79	6·78	·89	·85	·04	290·49	4 46	5 26
19	0·78	6·83	0·91	0·86	0·04	270·78	6 7	6 47
21	0·77	6·88	·92	·86	·04	251·08	7 28	8 8
23	0·75	6·93	·94	·87	·05	231·39	8 49	9 29
25	0·74	6·99	·95	·88	·05	211·72	10 10	10 50
27	0·73	7·04	·96	·89	·06	192·06	11 31	12 11
29	0·71	7·09	0·98	0·89	0·06	172·42	12 51	13 32
July 1	0·70	7·15	1·00	·90	·07	152·79	14 12	14 52
3	0·69	7·20	1·01	·91	·07	133·16	15 33	16 13
5	0·67	7·26	1·02	·91	·08	113·55	16 53	17 34
7	0·66	7·32	1·03	·92	·09	93·96	18 14	18 54
9	0·64	7·37	1·05	0·93	0·09	74·38	19 34	20 15
11	0·63	7·43	1·06	·93	·10	54·81	20 55	21 35
13	0·62	7·49	1·08	·94	·10	35·26	22 15	22 55
15	0·60	7·56	1·09	·94	·11	15·72	23 35	...
17	0·59	7·62	1·10	·95	·11	356·20	0 15	0 55
19	0·57	7·68	1·12	0·96	0·12	336·69	1 36	2 16
21	0·55	7·75	1·13	·96	·13	317·19	2 56	3 36
23	0·54	7·82	1·15	·97	·13	297·71	4 16	4 56

Greenwich Noon.	P.	L−O.	B.	A−L.	*B.*	Q.	E.
1896.	°	°	°	°	°	°	°
July 25	321·32	144·389	13·75	46·59	25·00	253·07	45·13
27	321·37	145·651	13·27	46·48	24·93	253·47	45·21
29	321·44	146·899	−12·78	−46·36	−24·84	253·88	45·28
31	321·54	148·133	12·29	46·23	24·74	254·30	45·34
Aug. 2	321·66	149·354	11·80	46·09	24·62	254·72	45·39
4	321·79	150·561	11·30	45·95	24·49	255·15	45·43
6	321·94	151·754	10·81	45·80	24·36	255·58	45·47
8	322·11	152·932	−10·32	−45·64	−24·21	256·02	45·50
10	322·29	154·096	9·83	45·47	24·05	256·46	45·52
12	322·49	155·245	9·34	45·29	23·87	256·90	45·53
14	322·71	156·380	8·85	45·10	23·69	257·35	45·53
16	322·94	157·500	8·36	44·91	23·50	257·80	45·52
18	323·19	158·606	− 7·88	−44·71	−23·29	258·25	45·50
20	323·45	159·697	7·40	44·50	23·08	258·70	45·47
22	323·72	160·773	6·93	44·28	22·85	259·15	45·43
24	324·00	161·835	6·46	44·06	22·62	259·60	45·38
26	324·30	162·881	5·99	43·83	22·37	260·05	45·32
28	324·60	163·912	− 5·53	−43·59	−22·12	260·50	45·24
30	324·91	164·927	5·08	43·35	21·86	260·94	45·15
Sept. 1	325·23	165·925	4·63	43·10	21·59	261·38	45·05
3	325·56	166·907	4·19	42·84	21·31	261·82	44·93
5	325·90	167·871	3·75	42·56	21·02	262·26	44·80
7	326·24	168·817	− 3·32	−42·28	−20·72	262·69	44·65
9	326·58	169·745	2·91	41·99	20·42	263·11	44·49
11	326·92	170·654	2·50	41·69	20·11	263·53	44·31
13	327·27	171·543	2·11	41·38	19·79	263·94	44·11
15	327·62	172·412	1·73	41·06	19·46	264·34	43·89
17	327·97	173·261	− 1·35	−40·72	−19·13	264·73	43·65
19	328·32	174·089	0·98	40·37	18·79	265·12	43·39
21	328·66	174·895	0·63	40·01	18·45	265·49	43·11
23	329·00	175·678	− 0·29	39·63	18·10	265·85	42·81
25	329·34	176·437	+ 0·03	39·24	17·74	266·20	42·48
27	329·67	177·171	+ 0·34	−38·83	−17·38	266·54	42·13
29	330·00	177·880	0·63	38·40	17·01	266·86	41·75
Oct. 1	330·32	178·561	0·91	37·95	16·64	267·17	41·34
3	330·62	179·214	1·18	37·49	16·26	267·46	40·91
5	330·92	179·837	1·43	37·01	15·88	267·73	40·45
7	331·20	180·429	+ 1·65	−36·50	−15·49	267·99	39·95

Greenwich Noon. 1896.	Brightness.	Appar. Diam.	Defect of Illumination q Equat.	Polar.	Central Meridian. ω_0	Passage of Zero Meridian.	
	m	″	″	″	°	h m	h m
July 25	0·52	7·88	1·16	·97	·14	278·24	5 36	6 16
27	0·51	7·95	1·18	·98	·14	258·78	6 56	7 36
29	0·49	8·03	1·19	0·99	0·15	239·34	8 16	8 56
31	0·47	8·10	1·20	0·99	·16	219·91	9 36	10 16
Aug. 2	0·46	8·17	1·22	1·00	·16	200·49	10 56	11 36
4	0·44	8·25	1·23	1·00	·17	181·09	12 15	12 55
6	0·42	8·33	1·24	1·01	·17	161·70	13 35	14 15
8	0·40	8·41	1·26	1·02	0·18	142·33	14 55	15 35
10	0·39	8·49	1·27	1·02	·19	122·97	16 14	16 54
12	0·37	8·58	1·28	1·03	·19	103·63	17 34	18 13
14	0·35	8·66	1·30	1·04	·20	84·30	18 53	19 33
16	0·33	8·75	1·31	1·04	·20	64·99	20 12	20 52
18	0·31	8·84	1·32	1·05	0·21	45·69	21 32	22 11
20	0·29	8·94	1·33	1·05	·21	26·41	22 51	23 31
22	0·27	9·03	1·35	1·06	·22	7·14	...	0 10
24	0·24	9·13	1·36	1·06	·22	347·89	0 50	1 29
26	0·22	9·23	1·37	1·07	·23	328·65	2 9	2 48
28	0·20	9·33	1·38	1·08	0·23	309·43	3 28	4 7
30	0·18	9·44	1·39	1·08	·23	290·22	4 47	5 26
Sept. 1	0·15	9·55	1·40	1·09	·24	271·03	6 6	6 45
3	0·13	9·66	1·41	1·09	·24	251·86	7 24	8 4
5	0·10	9·78	1·42	1·10	·25	232·70	8 43	9 22
7	0·08	9·90	1·43	1·10	0·25	213·56	10 2	10 41
9	0·05	10·02	1·44	1·11	·25	194·44	11 20	12 0
11	0·03	10·15	1·44	1·11	·25	175·34	12 39	13 18
13	0·00	10·28	1·45	1·11	·26	156·26	13 57	14 36
15	−0·03	10·41	1·45	1·12	·26	137·20	15 15	15 55
17	−0·06	10·55	1·46	1·12	0·26	118·15	16 34	17 13
19	−0·09	10·69	1·46	1·12	·26	99·13	17 52	18 31
21	−0·12	10·83	1·46	1·12	·26	80·14	19 10	19 49
23	−0·15	10·98	1·46	1·12	·26	61·16	20 28	21 7
25	−0·18	11·14	1·46	1·12	·27	42·21	21 45	22 24
27	−0·21	11·30	1·46	1·12	0·27	23·29	23 3	23 42
29	−0·24	11·46	1·45	1·12	·27	4·39	...	0 21
Oct. 1	−0·28	11·63	1·45	1·12	·26	345·52	0 59	1 38
3	−0·31	11·80	1·44	1·11	·26	326·67	2 17	3 56
5	−0·35	11·97	1·43	1·11	·26	307·85	3 35	4 13
7	−0·38	12·15	1·42	1·10	0·26	289·07	4 51	5 30

Greenwich Noon. 1896.	P.	L−O.	B.	A−L.	B.	Q.	E.
	°	°	°	°	°	°	°
Oct. 9	331·47	180·988	1·86	35·96	15·10	268·23	39·42
11	331·73	181·514	2·05	35·40	14·71	268·44	38·85
13	331·97	182·005	2·22	34·81	14·31	268·63	38·24
15	332·19	182·459	2·36	34·20	13·91	268·80	37·60
17	332·39	182·876	+ 2·48	−33·55	−13·51	268·95	36·92
19	332·58	183·254	2·59	32·87	13·10	269·07	36·20
21	332·74	183·591	2·67	32·16	12·69	269·16	35·44
23	332·88	183·886	2·73	31·41	12·28	269·23	34·63
25	333·00	184·137	2·76	30·62	11·86	269·26	33·77
27	333·09	184·343	+ 2·77	−29·80	−11·44	269·26	32·87
29	333·16	184·502	2·75	28·94	11·02	269·22	31·92
31	333·20	184·613	2·71	28·03	10·60	269·15	30·91
Nov. 2	333·21	184·673	2·64	27·08	10·18	269·04	29·86
4	333·20	184·683	2·54	26·09	9·75	268·88	28·75
6	333·15	184·642	+ 2·41	−25·05	− 9·33	268·67	27·58
8	333·08	184·549	2·26	23·97	8·90	268·42	26·36
10	332·98	184·404	2·08	22·84	8·47	268·12	25·09
12	332·85	184·206	1·87	21·66	8·04	267·76	23·76
14	332·69	183·957	1·63	20·44	7·61	267·33	22·38
16	332·50	183·659	+ 1·37	−19·17	− 7·18	266·82	20·95
18	332·29	183·313	1·08	17·86	6·74	266·23	19·47
20	332·05	182·919	0·77	16·50	6·31	265·54	17·93
22	331·79	182·479	0·44	15·11	5·88	264·73	16·35
24	331·51	181·997	+ 0·08	13·68	5·45	263·76	14·73
26	331·21	181·476	− 0·29	−12·21	− 5·02	262·59	13·08
28	330·89	180·919	0·67	10·71	4·58	261·13	11·39
30	330·57	180·331	1·07	9·19	4·15	259·24	9·68
Dec. 2	330·23	179·716	1·48	7·64	3·72	256·66	7·95
4	329·88	179·079	1·90	6·08	3·28	252·83	6·23
6	329·53	178·426	− 2·32	− 4·50	− 2·85	246·34	4·53
8	329·19	177·764	2·74	2·92	2·42	232·93	2·93
10	328·85	178·098	3·16	− 1·33	1·99	197·57	1·77
12	328·51	176·435	3·57	+ 0·24	1·56	136·09	2·20
14	328·19	175·780	3·97	1·81	1·14	115·63	3·36
16	327·88	175·138	− 4·36	+ 3·36	− 0·71	105·19	4·96
18	327·58	174·515	4·73	4·88	− 0·28	99·76	6·60
20	327·30	173·916	5·18	6·38	+ 0·14	96·41	8·24
22	327·04	173·346	5·41	7·85	0·56	94·08	9·86

Greenwich Noon. 1896.		Bright-ness.	Appar. Diam.	Defect of Illumination q Equat.	Polar.	Central Meridian. ω_0	Passage of Zero Meridian.	
		m	″	″	″	°	h m	h m
Oct.	9	−0·42	12·34	1·41	1·09 ·26	270·32	6 8	6 47
	11	−0·46	12·53	1·39	1·08 ·25	251·60	7 25	8 4
	13	−0·50	12·72	1·37	1·06 ·25	232·92	8 42	9 20
	15	−0·54	12·92	1·34	1·05 ·25	214·27	9 58	10 37
	17	−0·58	13·12	1·32	1·03 0·24	195·66	11 15	11 53
	19	−0·62	13·33	1·29	1·01 ·24	177·09	12 31	13 9
	21	−0·66	13·53	1·26	0·98 ·23	158·56	13 48	14 26
	23	−0·70	13·74	1·22	0·96 ·22	140·07	15 4	15 41
	25	−0·74	13·96	1·18	0·93 ·21	121·62	16 19	16 56
	27	−0·79	14·18	1·13	0·90 0·21	103·22	17 34	18 12
	29	−0·83	14·39	1·09	0·86 ·20	84·87	18 49	19 27
	31	−0·87	14·61	1·04	0·83 ·19	66·56	20 4	20 42
Nov.	2	−0·92	14·83	0·99	0·79 ·18	48·31	21 19	21 57
	4	−0·96	15·05	0·93	0·74 ·17	30·10	22 34	23 11
	6	−1·01	15·26	0·87	0·70 0·15	11·94	23 48	...
	8	−1·05	15·47	·80	·65 ·14	353·84	0 25	1 2
	10	−1·09	15·67	·74	·60 ·13	335·78	1 39	2 16
	12	−1·14	15·87	·67	·55 ·12	317·78	2 53	3 30
	14	−1·18	16·06	·60	·50 ·10	299·83	4 7	4 44
	16	−1·22	16·24	0·54	0·44 0·09	281·92	5 20	5 57
	18	−1·26	16·41	·47	·39 ·08	264·07	6 33	7 10
	20	+1·30	16·56	·40	·34 ·06	246·26	7 46	8 23
	22	−1·34	16·70	·34	·29 ·05	228·49	8 59	9 36
	24	−1·38	16·82	·28	·24 ·04	210·76	10 12	10 48
	26	−1·41	16·93	0·22	0·19 0·03	193·07	11 25	12 1
	28	−1·44	17·01	·17	·15 ·02	175·42	12 37	13 13
	30	−1·47	17·07	·12	·11 ·01	157·80	13 49	14 25
Dec.	2	−1·50	17·11	·08	·08 ·01	140·20	15 1	15 37
	4	−1·52	17·12	·05	·05 ·00	122·62	16 13	16 49
	6	−1·54	17·11	0·03	0·03 ...	105·06	17 25	18 1
	8	−1·56	17·07	·01	·01 ...	87·50	18 37	19 13
	10	−1·56	17·01	·00	·00 ·00	69·95	19 49	20 25
	12	−1·54	16·92	·01	... ·01	52·39	21 1	21 37
	14	−1·50	16·81	·01	·00 ·01	34·82	22 13	22 49
	16	−1·46	16·68	0·03	0·01 0·02	17·24	23 25	...
	18	−1·41	16·53	·05	·03 ·02	359·63	0 1	0 37
	20	−1·36	16·36	·08	·05 ·03	342·00	1 14	1 50
	22	−1·31	16·16	·12	·08 ·04	324·34	2 26	3 2

Greenwich Noon.	P.	L−O.	B.	A−L.	*B.*	Q.	E.
1896.	°	°	°	°	°	°	°
Dec. 24	326·79	172·808	5·72	9·28	0·98	92·36	11·44
26	326·57	172·305	− 6·00	+ 10·68	+ 1·40	91·00	12·98
28	326·37	171·840	6·25	12·04	1·82	89·90	14·48
30	326·19	171·416	6·48	13·35	2·24	88·98	15·93
1897.							
Jan. 1	326·03	171·037	6·68	14·61	2·65	88·20	17·33
3	325·89	170·704	6·86	15·83	3·07	87·54	18·67
5	325·77	170·417	− 7·01	+ 17·00	+ 3·48	86·97	19·95
7	325·68	170·178	7·13	18·12	3·89	86·48	21·18
9	325·61	169·987	7·22	19·19	4·30	86·06	22·35
11	325·55	169·844	7·29	20·21	4·70	85·69	23·46
13	325·52	169·749	7·33	21·18	5·10	85·38	24·52
15	325·50	169·701	− 7·34	+ 22·10	+ 5·50	85·11	25·52
17	325·51	169·699	7·33	22·98	5·90	84·89	26·47
19	325·53	169·741	7·29	23·81	6·30	84·71	27·36
21	325·57	169·826	7·23	24·60	6·69	84·56	28·20
23	325·62	169·953	7·14	25·34	7·08	84·45	29·00
25	325·69	170·120	− 7·03	+ 26·04	+ 7·47	84·37	29·75
27	325·78	170·327	6·91	26·70	7·85	84·32	30·45
29	325·88	170·572	6·76	27·32	8·23	84·30	31·10
31	326·00	170·853	6·60	27·91	8·61	84·30	31·71
Feb. 2	326·14	171·170	6·42	28·46	8·99	84·33	32·28
4	326·29	171·520	− 6·21	+ 28·98	+ 9·36	84·38	32·81
6	326·45	171·902	5·99	29·46	9·73	84·45	33·30
8	326·63	172·315	5·76	29·92	10·10	84·55	33·75
10	326·83	172·758	5·51	30·34	10·47	84·67	34·17
12	327·04	173·229	5·25	30·73	10·83	84·81	34·56
14	327·27	173·726	− 4·97	+ 31·10	+ 11·19	84·96	34·92
16	327·51	174·248	4·68	31·45	11·54	85·13	35·24
18	327·76	174·794	4·38	31·87	11·89	85·32	35·53
20	328·03	175·363	4·06	32·07	12·24	85·52	35·80
22	328·31	175·953	3·73	32·35	12·58	85·74	36·04
24	328·60	176·564	− 3·39	+ 32·60	+ 12·92	85·97	36·26
26	328·91	177·195	3·05	32·84	13·26	86·22	36·45
28	329·23	177·844	2·69	33·06	13·60	86·48	36·62
Mar. 2	329·57	178·511	2·32	33·26	13·93	86·75	36·77
4	329·92	179·196	1·95	33·45	14·25	87·03	36·89
6	330·28	179·899	− 1·57	+ 33·62	+ 14·57	87·32	36·99

Greenwich Noon.	Bright-ness.	Appar. Diam.	Defect of Illumination q Equat.	Polar.	Central Meridian. ω_0	Passage of Zero Meridian.	
1896.	m	″	″	″	°	h m	h m
Dec. 24	−1·26	15·69	·16	·11	·05	306·65	3 39
							4 15
26	−1·20	15·74	0·20	0·14	0·06	288·92	4 51
							5 28
28	−1·14	15·50	·25	·17	·07	271·15	6 4
							6 41
30	−1·08	15·26	·29	·21	·08	253·34	7 17
							7 54
1897.							
Jan. 1	−1·00	15·01	·34	·24	·09	235·48	8 31
							9 7
3	−0·96	14·75	·39	·28	·10	217·57	9 44
							10 21
5	−0·90	14·48	0·44	0·31	0·11	199·62	10 58
							11 35
7	−0·84	14·22	·48	·35	·12	181·62	12 12
							12 49
9	−0·78	13·95	·52	·39	·13	163·57	13 26
							14 3
11	−0·71	13·68	·57	·42	·14	145·47	14 40
							15 17
13	−0·65	13·41	·61	·45	·14	127·32	15 54
							16 32
15	−0·59	13·14	0·64	0·48	0·15	109·12	17 9
							17 47
17	−0·53	12·88	·68	·51	·16	90·88	18 25
							19 2
19	−0·47	12·62	·71	·53	·16	72·59	19 40
							20 17
21	−0·41	12·36	·73	·55	·16	54·26	20 55
							21 33
23	−0·35	12·11	·76	·57	·17	35·88	22 10
							22 48
25	−0·29	11·86	0·78	0·59	0·17	17·46	23 26
							...
27	−0·23	11·62	·80	·61	·17	359·00	0 4
							0 42
29	−0·18	11·38	·82	·62	·17	340·51	1 20
							1 58
31	−0·12	11·15	·83	·63	·18	321·98	2 36
							3 14
Feb. 2	−0·06	10·92	·84	·64	·18	303·41	3 52
							4 30
4	−0·01	10·70	0·85	0·65	0·18	284·80	5 9
							5 47
6	0·04	10·49	·86	·66	·18	266·17	6 25
							7 3
8	0·10	10·28	·87	·66	·18	247·50	7 42
							8 20
10	0·15	10·08	·87	·67	·18	228·80	8 59
							9 37
12	0·20	9·89	·87	·67	·18	210·08	10 16
							10 54
14	0·25	9·70	0·87	0·67	0·18	191·33	11 33
							12 11
16	0·30	9·51	·87	·67	·17	172·55	12 50
							13 29
18	0·35	9·33	·87	·67	·17	153·75	14 7
							14 46
20	0·39	9·16	·87	·66	·17	134·93	15 24
							16 3
22	0·44	8·99	·86	·66	·17	116·09	16 42
							17 21
24	0·48	8·83	0·85	0·66	0·17	97·22	17 59
							18 38
26	0·53	8·67	·85	·65	·16	78·33	19 17
							19 56
28	0·57	8·52	·84	·65	·16	59·42	20 35
							21 14
Mar. 2	0·61	8·38	·83	·64	·16	40·50	21 52
							22 31
4	0·65	8·23	·82	·64	·16	21·56	23 10
							23 49
6	0·69	8·09	0·81	0·63	0·15	2·60	...
							0 28

Greenwich Noon.	P.	L−O.	B.	Δ−L.	B.	Q.	E.
1897.	°	°	°	°	°	°	°
Mar. 8	330·66	180·617	1·18	33·78	14·89	87·63	37·07
10	331·05	181·350	0·78	33·92	15·21	87·95	37·14
12	331·45	182·098	− 0·37	34·05	15·52	88·28	37·19
14	331·86	182·860	+ 0·04	34·16	15·83	88·61	37·22
16	332·29	183·635	+ 0·45	+ 34·26	+ 16·13	88·95	37·24
18	332·73	184·422	0·87	34·36	16·43	89·30	37·24
20	333·18	185·221	1·30	34·44	16·72	89·66	37·23
22	333·64	186·032	1·73	34·51	17·01	90·03	37·21
24	334·12	186·855	2·17	34·57	17·30	90·40	37·17
26	334·61	187·689	+ 2·61	+ 34·62	+ 17·58	90·78	37·12
28	335·10	188·533	3·05	34·66	17·86	91·16	37·05
30	335·61	189·388	3·50	34·69	18·14	91·55	36·97
Apr. 1	336·13	190·254	3·95	34·72	18·41	91·94	36·89
3	336·66	191·130	4·40	34·74	18·67	92·34	36·79
5	337·20	192·016	+ 4·85	+ 34·74	+ 18·93	92·74	36·68
7	337·76	192·912	5·31	34·74	19·19	93·14	36·56
9	338·32	193·817	5·77	34·73	19·44	93·55	36·44
11	338·89	194·731	6·23	34·72	19·69	93·96	36·30
13	339·47	195·655	6·69	34·70	19·93	94·37	36·16
15	340·06	196·587	+ 7·15	+ 34·67	+ 20·17	94·78	36·00
17	340·66	197·528	7·61	34·63	20·40	95·20	35·84
19	341·27	198·477	8·07	34·59	20·62	95·62	35·67
21	341·88	199·435	8·54	34·54	20·84	96·03	35·50
23	342·50	200·402	9·00	34·48	21·06	96·45	35·31
25	343·13	201·377	+ 9·46	+ 34·42	+ 21·27	96·87	35·12
27	343·77	202·361	9·92	34·35	21·48	97·29	34·92
29	344·42	203·353	10·38	34·27	21·68	97·70	34·72
May 1	345·07	204·354	10·84	34·19	21·88	98·11	34·51
3	345 73	205·363	11·29	34·10	22·07	98·52	34·30
5	346·40	206·381	+ 11·75	+ 34·00	+ 22·26	98·93	34·08
7	347·08	207·408	12·20	33·90	22·44	99·34	33·86
9	347·76	208·443	12·65	33·79	22·62	99·75	33·63
11	348·45	209·486	13·09	33·68	22·79	100·15	33·39
13	349·14	210·538	13·53	33·56	22·95	100·55	33·15
15	349·84	211·598	+ 13·97	+ 33·43	+ 23·11	100·94	32·90

Greenwich Noon.	Bright-ness.	Appar. Diam.	Defect of Illumination q Equat.	Polar.	Central Meridian. ω_0	Passage of Zero Meridian.	
1897.	m	″	″	″	°	h m	h m
Mar. 8	0·73	7·96	·80	·62 ·15	343·63	1 7	1 46
10	0·77	7·83	·79	·62 ·15	324·64	2 25	3 4
12	0·81	7·70	·78	·61 ·15	305·63	3 43	4 22
14	0·85	7·58	·77	·60 ·14	286·61	5 2	5 41
16	0·88	7·47	0·76	0·59 0·14	267·58	6 20	6 59
18	0·92	7·35	·75	·59 ·14	248·54	7 38	8 17
20	0·95	7·24	·74	·58 ·13	229·48	8 56	9 35
22	0·99	7·13	·73	·57 ·13	210·42	10 15	10 54
24	1·02	7·03	·71	·56 ·13	191·34	11 33	12 12
26	1·05	6·93	0·70	0·55 0·13	172·25	12 51	13 31
28	1·08	6·83	·69	·54 ·12	153·15	14 10	14 49
30	1·11	6·74	·68	·54 ·12	134·04	15 28	16 8
Apr. 1	1·14	6·65	·67	·53 ·12	114·91	16 47	17 26
3	1·17	6·56	·65	·52 ·11	95·78	18 6	18 45
5	1·20	6·47	0·64	0·51 0·11	76·64	19 24	20 4
7	1·23	6·39	·63	·50 ·11	57·49	20 43	21 23
9	1·25	6·31	·62	·49 ·10	38·33	22 2	22 41
11	1·28	6·23	·60	·49 ·10	19·16	23 21	...
13	1·31	6·15	·59	·48 ·10	359·98	0 0	0 39
15	1·33	6·08	0·58	0·47 0·09	340·79	1 19	1 58
17	1·36	6·00	·57	·46 ·09	321·60	2 38	3 17
19	1·38	5·93	·56	·45 ·09	302·40	3 57	4 36
21	1·40	5·87	·55	·45 ·08	283·19	5 16	5 55
23	1·43	5·80	·53	·44 ·08	263·97	6 35	7 14
25	1·45	5·74	0·52	0·43 0·08	244·74	7 54	8 33
27	1·47	5·67	·51	·42 ·07	225·50	9 13	9 52
29	1·49	5·61	·50	·41 ·07	206·25	10 32	11 11
May 1	1·51	5·56	·49	·41 ·07	187·00	11 51	12 31
3	1·53	5·50	·48	·40 ·07	167·74	13 10	13 50
5	1·55	5·44	0·47	0·39 0·06	148·47	14 29	15 9
7	1·57	5·39	·46	·39 ·06	129·19	15 48	16 28
9	1·59	5·34	·45	·38 ·06	110·90	17 8	17 48
11	1·60	5·29	·44	·37 ·06	90·61	18 27	19 7
13	1·62	5·24	·43	·36 ·05	71·31	19 47	20 26
15	1·64	5·19	0·42	0·36 0·05	52·01	21 6	

In the preparation of the present ephemeris I have, not without hesitation, adopted the position of the axis of *Mars* which Hermann Struve has deduced from his investigation of the orbits of the satellites, published in No. 3302 of the *Astron. Nachrichten.* The inclination of the equator to the orbit of *Mars* is increased 0°·344, but the node on the orbit set back 2°·973, and it is a question whether the foundation for the new determination is already sufficiently secure to warrant its superseding the previous determination from spots. Nevertheless, I have considered it better to make the change, especially as the computed areographical positions of the Earth and Sun will serve for the satellites as well as for the planet.

P denotes the position-angle of the axis of *Mars*, L − O + 180° the longitude of the Earth referred to the plane of *Mars*' equator, and reckoned from O, the point of the vernal equinox of the planet's northern hemisphere, B the latitude of the Earth, Λ − L the difference of the longitudes of Sun and Earth, *B* the latitude of the Sun, Q the position angle of the greatest defect of illumination or Q + 180° that of the Sun, E the areocentric angle between Earth and Sun.

The brightness of *Mars*, expressed in star magnitudes, is computed by Professor G. Müller's formula—

$$-1^{m}\cdot 787+5\log\frac{r\Delta}{r_0(r_0-1)}+0\cdot 01486\alpha \text{ (here E)},$$

or rather by its equivalent—

$$+5\log(r\Delta)+0\cdot 01486\,\mathrm{E}+0\cdot 703-2,$$

in which the defect of illumination is assumed to be represented by the empirical term containing the angle E expressed in degrees.

The measures of the planet's diameter made with powerful instruments and wire micrometers, demand the assumption of a larger value than that derived from measures made with heliometers of rather low power, but the most suitable assumption can only be made when the resulting measures of the equatorial and polar diameters for each observed set are published, so that the corrections for phase may be properly applied.

If a web or a line is moved in the direction of the position-angle p or $p+180°$, the distance of the tangent to the curve forming the limit of illumination from the centre will be

$$a\sqrt{1-\sin^2\mathrm{E}\cos^2(p-\mathrm{Q})},$$

or the difference between the diameter $2a$ and the distance of the two tangents touching the visible disc will be

$$2a\left(1-\sqrt{1-\sin^2\mathrm{E}\cos^2(p-\mathrm{Q})}\right),$$

so that the defect of illumination is

$$2a\sin^2\tfrac{1}{2}\delta, \text{ if } \sin\delta=\sin\mathrm{E}\cos p-\mathrm{Q}.$$

For the equatorial and polar diameters the values of sin δ are accordingly sin E sin (P−Q) and sin E cos (P−Q) and for the diameters in position-angle 90° and 0° sin E sin Q and sin E cos Q, the visible defect being within 90° of Q.

The apparent diameters and the defects of illumination q in position-angle Q and of the equatorial and polar diameters are computed with the assumed value (at distance 1) 9″·60.

The difference of about 5°, which Mr. Percival Lowell has found between the areographical longitudes of some spots derived from his observations of 1894 and the corresponding longitudes of *Schiaparelli*, which the ephemeris was intended to represent approximately, requires to be traced to its source and to be cleared up. A search for some error in my computations, which might account for the difference, has hitherto been unsuccessful, and an alteration of the adopted rate of rotation, such as would reconcile the deduced longitudes of 1894 with those of 1879, could not be reconciled with the older observations. Under these circumstances I have had to defer the further search for the source of the error and to break the continuity of the "Longitudes of the Central Meridian" by adopting in the present ephemeris approximate alterations derived from Mr. Lowell's statements. When the detailed observations of 1896–97 as well as of 1894 shall have become known, I intend to resume the search.

The data of the ephemeris are already corrected for the equation of light, so that they are to be interpolated directly for the times for which they are required. The differences between successive values of ω_0, the longitude of the central meridian, vary between 700°·16 and 702°·45.

The ephemeris for the opposition of 1886 in vol. xlvi. of the *Monthly Notices* is accompanied on p. 33 by some remarks, which observers will perhaps bear in mind during the approaching observing season. "It is desirable that the question should be settled how far the variations in the aspect of the dark markings on *Mars* are due to the relative position of the Sun and the Earth, and especially what changes take place in the aspect of a marking, when, in the course of rotation, it reaches or leaves the vicinity of the point where Sun and Earth have the same zenith distances, but opposite azimuths." This point is in position-angle Q + 180 and at the areocentric angular distance $\frac{1}{2}$E from the apparent centre of the disc, but as "observers may perhaps be more readily induced to watch their opportunities, if they can easily get the areographical longitude ω' and latitude β' of the point," I gave there a special little list. As the present ephemeris contains the values of $\Lambda - L$ and of B referring to the Sun, the areographical position of the point where the effect of reflected sunlight may be looked for is approximately—

$$\omega' - \omega_0 = -\tfrac{1}{2}(\Lambda - L)$$
$$\beta' = \tfrac{1}{2}(B + B).$$

The seasons on *Mars* begin according to the assumed position of the planet's equator

1896 July 13·7 Winter solstice of *Mars'* northern hemisphere
Dec. 19·3 Spring equinox „ „ „

On April 8, at $1^h\ 32^m$ Gr. *Mars* passes $2'{\cdot}1$ south of the star $3^m{\cdot}2\ \epsilon$ *Geminorum*.

Col. Cooper's Observatory:
Markree, Collooney, Ireland.